The reports from cooperative observers for October show a general and moderately heavy rainfall over the State on the 10th. No remarkably heavy amounts were recorded on that day, although the observers at many stations measured amounts of from 1 to 2 inches. Thunderstorms were numerous and at a number of places they were accompanied by hail and destructive wind. The observer at Osceola, a station about 180 miles northwest of the principal tornado track, had the largest 24-hour rainfall, amounting to 2.30 inches.

The second tornado which occurred near Beloit, in Rock County, in the later afternoon was much less severe. It occurred at 4.20 p. m., traveling from southwest to northeast, with length of path about 1 mile. It was of short duration and the width of its path ranged from 8 to 40 rods. Correspondents at Beloit all report a pendent, funnel-shaped cloud with rotary winds. The loss from this storm amounted to about $20,000, which is included in the estimate of $250,000 as a total loss for the entire district. Six people were injured during the tornado near Beloit, and a dozen cattle, two horses, and numerous pigs and chickens were killed, and two houses and six barns were destroyed.

RAINFALL AND SPRING WHEAT.

T. A. BLAIR, Observer, Minneapolis, Minn.

A statistical study of the relations between climates and crops has shown, in a few instances, a very definite correlation between yield and rainfall. In the wheat districts of southern Australia there is a practically constant difference of 6 between the rainfall in inches and the yield of wheat in bushels per acre; and in Jamaica and Barbados the sugar production can be predicted within 3 per cent from the rainfall data. (Hann, Climatology, p. 58.) Although the relations between climates and crops are in general much more complicated, and no one climatic element has such a predominating influence as precipitation in the cases cited above. Nevertheless the supply of moisture during the growing season is one of the largest factors in the production of the staple crops of all countries. The following table and charts have been prepared with a view to ascertaining to what extent the monthly precipitation influences the yield of wheat in the three great spring-wheat-producing States of Minnesota, North Dakota, and South Dakota.

In these States wheat is seeded during April and harvested during the latter half of July and in August. There is always sufficient moisture in the ground in April to start the plant, and by July it has attained its height and is heading, at which time warmth and sunshine are needed and much rainfall is injurious. It is during May and June, therefore, while the plant is growing most rapidly, that the favorable effects of precipitation should be most noticeable. Accordingly, the total rainfall for May and June has been used in making this comparison. The first column for each of the States is the precipitation by years; the second column the departure from the average of the years used; the third is the yield of wheat in bushels per acre, and the fourth the like departure from the average. The rainfall figures used are the State averages obtained by the Weather Bureau, and the figures for yield are those of the Bureau of Statistics, as published in the Yearbooks of the Department of Agriculture. The charts have been so drawn that the two curves for each State have the same base line and the same line representing average values, thus facilitating the direct comparison of the two quantities.

It will be noted that the curves for South Dakota show a remarkably close correspondence between yield and rainfall for several of the years, but considerable divergences in other years; the same is true of North Dakota, while Minnesota shows more marked divergences and less correlation. In particular, the four wettest seasons in Minnesota, in which the rainfall exceeded 10 inches for the two months under consideration, each produced a crop that was below normal, while of the six years with yields decidedly above normal five had less than the average precipitation and the sixth only 0.4 inch above the average. It therefore appears that a wet May and June are distinctly unfavorable for wheat in Minnesota and that the best crops are obtained when the precipitation is normal or slightly less. One evident reason for this is the poor drainage of much of the land in Minnesota. Many fields produce better in dry years because, even in years of ordinary rainfall, they become waterlogged through lack of natural drainage. No such result appears in the Dakotas, where the drainage is better and where also the average precipitation is less, approaching more nearly a semiarid condition, and where for this reason a more direct response to increased rainfall might be expected.

In 10 out of the 22 years' record for Minnesota the departures are of opposite signs, thus indicating no direct relation. From this table the correlation coefficient was calculated in the usual manner (see article, Correlation, J. Warren Smith, Monthly Weather Review, May, 1911), and found to be a very small negative quantity. The 4 wet years above mentioned were then omitted and the coefficient found to be 0.26, with a possible error of 0.11. To show a close correlation the coefficient should not be less than 0.50 and must be six times the possible error. Obviously no such relation exists for wheat production and rainfall in Minnesota.

In the record for South Dakota there are 6 years with departures of opposite sign, but the departures are all small, except for the years 1910 and 1912, which had very light rainfall but above normal yields. The correlation coefficient for South Dakota is 0.59 and the possible error 0.06, showing a very distinct relation between the amount of rainfall in May and June and the resulting harvest. And this is largely true for the individual years, except for the two just mentioned. An especially close relation is shown for the period of 12 years, 1893 to 1904, inclusive, for which the coefficient is 0.87 and the possible error 0.025. The years with the heaviest rainfall show yields well above normal, but not equaling those of 1891 and 1912, when precipitation was below normal.

The correlation coefficient for the whole series of years is greatest in North Dakota, being 0.63, with a possible error of 0.05, but there is not as in South Dakota a long series of years showing a much closer relation. Here also there are 6 years with departures of opposite sign, in several of which there is a rather wide divergence. The years of greatest yield were 1895, 21 bushels, and 1912, 18 bushels, with precipitation, respectively, 1.3 inches and 0.7 inch above normal. The greatest rainfall was 8.7 inches in 1896 and 1906, and the yields in these years were, respectively, 0.4 bushel below the average and 0.8 above. Only in North Dakota was the year of minimum rainfall also the year of minimum yield; but in general, for all three States, years of light rainfall were years of light yield, the exceptions being Minnesota in 1910 and South Dakota in 1910 and 1912.

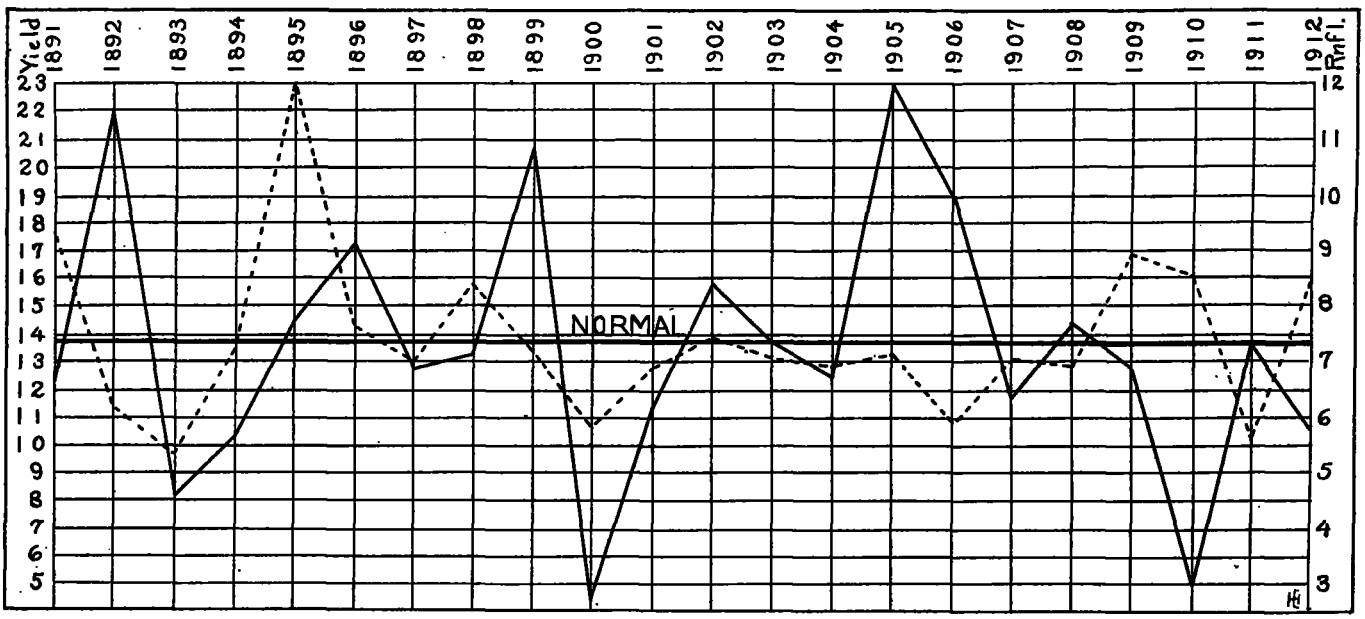
These years and that of 1911 in North Dakota are the seasons showing the least correspondence of precipitation and yield, and in these there is some indication of the influence of temperature, good yields in dry years being accompanied by cool weather in May, and poor yields in normally wet years by very warm weather. In 1910 the rainfall was very light in all the States, but the yield was above normal in Minnesota and South Dakota, and May

temperatures averaged 3° below normal in both States. In 1911 both rainfall and yield were very light in South Dakota, and temperatures for May were 4.7° above normal and for June 7.6° above. In 1912 there was again a light rainfall and a good yield, and in this case May temperatures were 0.5° above normal and June temperatures 1° below. In 1911 the rainfall in North Dakota was slightly above normal and the yield much below, the temperatures for May and June being, respectively, 2.8° and 4.9° above normal. The influence of temperature has not been further investigated.

Aside from the fact that this series is too short to establish any definite conclusions, there are of course other factors to be taken into account in considering yield, among which are the more particular distribution and timeliness of the rainfall, the weather of March and April and of the preceding autumn, and the methods of cultivation, these two latter factors being somewhat interrelated, as, for instance, a wet autumn prevents fall plowing and results in the sowing of grain on the stubble in the spring. But these brief tables do seem to confirm the idea that the total precipitation of May and June is in most years the largest factor in determining the wheat yield in the two Dakotas, but not in Minnesota.

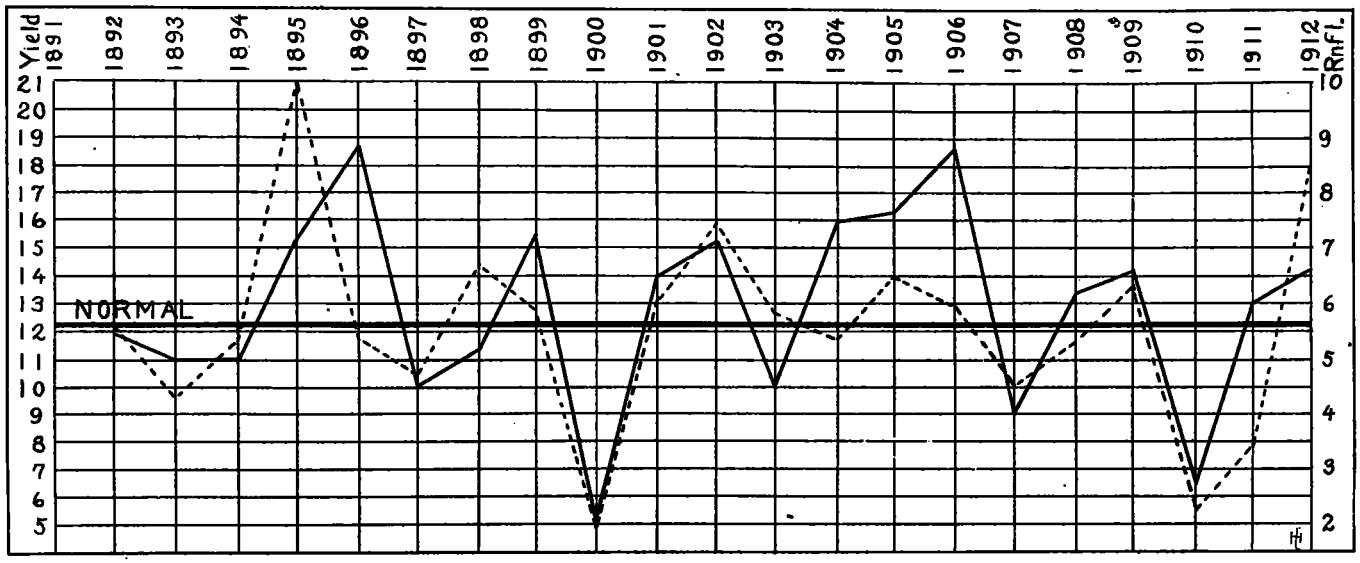
Rainfall and wheat yield, 1891–1912.

Year.	Minnesota.				North Dakota.				South Dakota.			
	Rainfall May and June.	Departure.	Yield.	Departure.	Rainfall May and June.	Departure.	Yield.	Departure.	Rainfall May and June.	Departure.	Yield.	Departure.
1891	6.6	−0.7	17.6	+3.8	.....	.....	.....	.....	6.5	−0.1	15.2	+3.9
1892	11.4	+4.1	11.6	−2.2	5.6	−0.3	12.2	0.0	9.5	+2.9	12.5	+1.2
1893	4.6	−2.7	9.6	−4.2	5.0	−0.9	9.6	−2.6	4.5	−2.1	8.5	−2.8
1894	5.7	−1.6	13.5	−0.3	5.0	−0.9	11.8	−0.4	3.7	−2.9	6.6	−4.7
1895	7.7	+0.4	23.0	+9.2	7.2	+1.3	21.0	+8.8	6.9	+0.3	12.0	+0.7
1896	9.1	+1.8	14.2	+0.4	8.7	+2.8	11.8	−0.4	6.6	0.0	11.2	−0.1
1897	6.9	−0.4	13.0	−0.8	4.5	−1.4	10.3	−1.9	4.6	−2.0	8.0	−3.3
1898	7.2	−0.1	15.8	+2.0	5.2	−0.7	14.4	+2.2	6.8	+0.2	12.4	+1.1
1899	10.8	+3.5	13.4	−0.4	7.3	+1.4	12.8	+0.6	8.1	+1.5	10.7	−0.6
1900	2.6	−4.7	10.5	−3.3	2.1	−3.8	4.9	−7.3	3.5	−3.1	6.9	−4.4
1901	6.2	−1.1	12.9	−0.9	6.5	+0.6	13.1	+0.9	8.1	+1.5	12.9	+1.6
1902	8.4	+1.1	13.9	+0.1	7.2	+1.3	15.9	+3.7	6.0	−0.6	12.2	+0.9
1903	7.3	0.0	13.1	−0.7	4.5	−1.4	12.7	+0.5	7.0	+0.4	13.8	+2.5
1904	6.7	−0.6	12.8	−1.0	7.5	+1.6	11.8	−0.4	6.5	−0.1	9.6	−1.7
1905	12.0	+4.7	13.3	−0.5	7.6	+1.7	14.0	+1.8	11.6	+5.0	13.7	+2.4
1906	10.1	+2.8	10.9	−2.9	8.7	+2.8	13.0	+0.8	8.4	+1.8	13.4	+2.1
1907	6.4	−0.9	13.0	−0.8	4.0	−1.9	10.0	−2.2	7.7	+1.1	11.2	−0.1
1908	7.6	+0.3	12.8	−1.0	6.3	+0.4	11.6	−0.6	10.0	+3.4	12.8	+1.5
1909	6.9	−0.4	16.8	+3.0	6.5	+0.6	13.7	+1.5	9.0	+2.4	14.1	+2.8
1910	3.0	−4.3	16.0	+2.2	2.8	−3.1	5.5	−6.7	3.9	−2.7	12.8	+1.5
1911	7.3	+0.0	10.1	−3.7	6.0	+0.1	8.0	−4.2	3.6	−3.0	4.0	−7.3
1912	5.8	−1.5	15.8	+2.0	6.6	+0.7	18.0	+5.8	3.8	−2.8	14.2	+2.9
Mean...	7.3	.....	13.8	.....	5.9	.....	12.2	.....	6.6	.....	11.3	.....

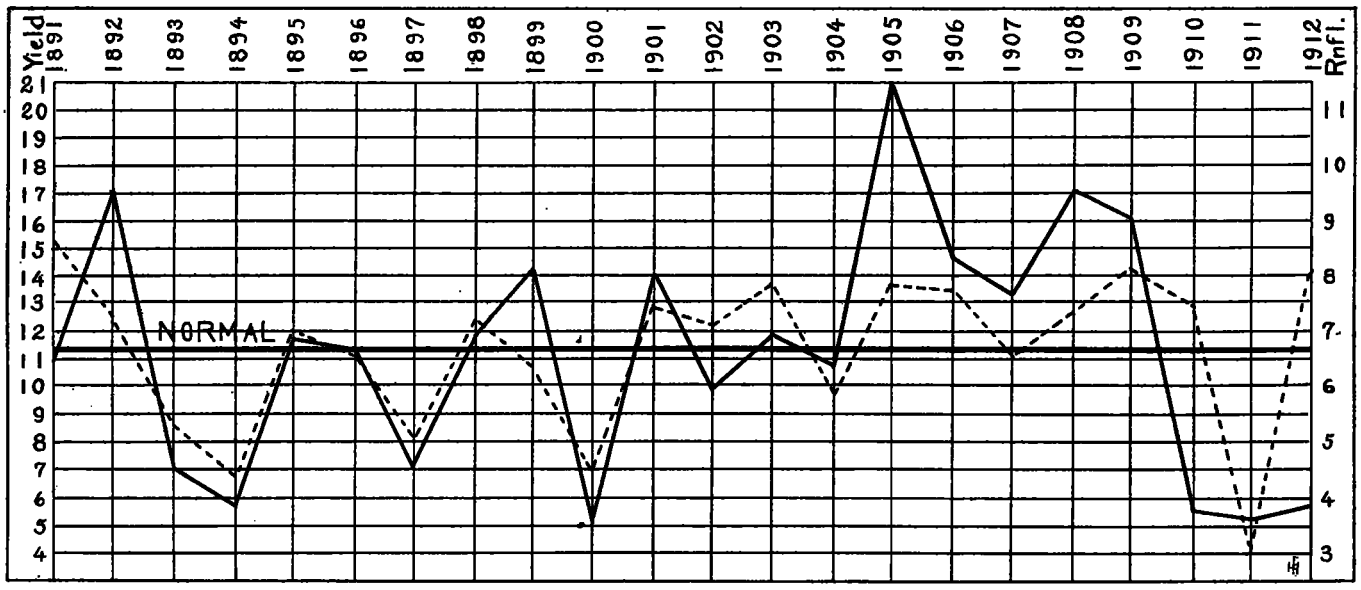


MINNESOTA: ..... Yield, in bushels, per acre.

_____ Rainfall, in inches, May and June.



NORTH DAKOTA: ------- Yield, in bushels, per acre.
——— Rainfall, in inches, May and June.



SOUTH DAKOTA: ------- Yield, in bushels, per acre.
——— Rainfall, in inches, May and June.